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Situation and outlook of solar energy utilization in Tibet, China

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ABSTRACT

The near-exponential rise in tourist numbers and accelerating economic growth have challenged Tibetan energy supply and threaten its peculiar environment and valuable ecosystem. Exploitation of pollution free solar power may medicate this demand for energy. Here we shall provide a review of solar power development in Tibet. This region has a near inexhaustible source of solar energy due to its average annual radiation intensity of 6000–8000 MJ/m^2, ranking it first in China and second after the Sahara worldwide. Currently, Tibet has 400 photovoltaic power stations with a total capacity of nearly 9 MW. In addition, 260,000 solar energy stoves, passive solar house heating covering 3 million square meters, and 400,000 m^2 of passive solar water heaters are currently in use in Tibet. Although Tibet places first in applying solar energy in China, solar energy faces big challenges from hydroelectric power and the absence of local know-how. The new power generation capacity in Tibet's "11th Five-Year (2006–2010)" Plan focuses primarily on hydropower, PV power stations being relegated to a secondary role as supplementary to hydropower. Here it will be argued that this emphasis is incorrect and that solar energy should take first place in Tibet's energy development, as it is crucial in striving for a balance between economic development, booming tourism, and environmental protection.

Contents

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1. Introduction

1.1. Ecological challenge confronting Tibet

With an average altitude over 4000 m, unique ecological and geographical features, rich wildlife and water resources, Tibet has been called the ''Roof of the World'' and the ''Third Pole of the Earth''. It is not only the ''Asia's water tower'', but also the ''starter'' and ''regulating area'' of the climate of China and indeed of the Eastern Hemisphere as a whole. Tibet has a peculiar environment and a valuable ecosystem [1].

Rapid economic growth and booming tourism have challenged the Tibetan ecosystem. Tibetan economy has maintained development growth above 12% for seven consecutive years [2]. In addition, the completion of the Qinghai-Tibet railway has promoted local tourism. Regional authorities estimate that by 2010 the number of tourists will double from the 2006 total of 2.5 million [3] (total population in Tibet is 2.68 million in 2006 [4]). Accelerating economic growth and the soaring tourist trade are inevitably accompanied by increasing energy consumption and increasing pollution, putting great pressure on the precious ecosystem of Tibet.

1.2. Energy challenges facing Tibet

Tibet is short of fossil energy resources. The theoretical reserves of coal resources are less than 50 million tons. The verified reserves of oil and gas are few [5]. In 2006, the output of coal was less than 30,000 tons [6]. Until now, most of the coal, oil and gas have been transported by road or pipeline from at least 1000 km away. Coal is mainly used for the cement industry, oil for transportation, and gas for cooking.

Energy consumption in Tibet is dominated by traditional biomass, such as cattle dung, firewood and crop straw, due to the long transportation distance and high cost of fossil energy. In 2003, the total energy consumption amounted to about 2 million tons of standard coal equivalent (tce), the share of traditional biomass utilization being nearly 70% [7,8]. Most biomass is directly burned as fuel for cooking and heating. The rarified Tibetan atmosphere and use of outdated stoves, result in a very low burning efficiency, utilizing less than 10% of the potential energy of biomass [9]. Biotic energy sources are becoming overused with the rapid urbanization, and excessive depletion of biotic energy sources has become a main factor responsible for deforestation, land desertification, soil erosion, grassland degradation and soil fertility reduction in Tibet [7,8,10–12].

On account of the near-exponential rise in tourism and rapid economic development, Tibet has no choice but to develop a non-polluting and renewable energy supply to sustain development while protecting its precious and fragile ecosystem.

1.3. Solar energy

Solar energy is obviously environmentally advantageous relative to any other energy source, and the linchpin of any serious sustainable development program. It does not deplete natural resources, does not cause CO_2 or other gaseous emission into air or generates liquid or solid waste products. Concerning sustainable development, the main direct or indirectly derived advantages of solar energy are the following [13,14]:

- No emissions of greenhouse (mainly CO_2, NO_x) or toxic gasses (SO_2, particulates);
- reclamation of degraded land;
- reduction of transmission lines from electricity grids;
- improvement of quality of water resources;
- increase of regional/national energy independence;
- diversification and security of energy supply;
- acceleration of rural electrification in developing countries.

2. Solar energy resources in Tibet

Tibet is the main parts of the Qinghai-Tibet Plateau located in the southwest border area of China between 78′25–90′06E longitude and 26′50–36′53N latitude, the last latitude being similar to that of Algiers. Its annual average sunlight ranges between 1600 and 3400 h, the highest in China [15]. The average annual number of days with 6 h of sunshine is 275–330. Direct irradiation accounts for 56–78% of the total yearly solar radiation, and for 71–88% of the total solar radiation in summer. The solar irradiation intensity decreases from East to West [16] (see Fig. 1). The transparency of the Tibetan atmosphere is high: the atmosphere is rarified and the water and dust content low. As a consequence the average annual radiation intensity reaches 6000–8000 MJ/m^2 in Tibet, second worldwide after the Sahara. The distribution of solar energy potential is uneven because of differences in geographical location and climatic conditions (Table 1).

Four zones of solar energy resources may be distinguished according to their solar energy radiative quantity [15,16]:

- Solar energy resources in western and northern Tibet are the richest, having two-thirds of the total solar energy resources in Tibet. This region receives an annual radiation of 7000–8400 MJ/m^2 and 2900–3400 h of sunshine. The average annual number of days with more than 6 h of sunshine varies between 275 and 330.

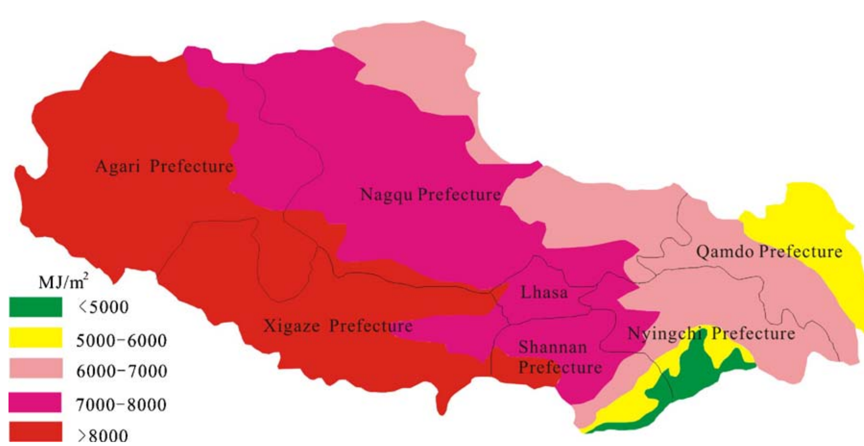

Fig. 1. The distribution of solar energy in Tibet, China (from www.weatherinfo.com.cn/zy/gnzy.html).

Table 1
Solar energy distribution in Tibet [17].

Location	Sunshine (h)	Annual radiation intensity (MJ/m^2)	Area (km^2)	Elevation (m^2)
Lhasa	3000	7500–8000	29,520	3700
Ngari	3300	7000–8000	30,500	4500
Shannan	2900	7000–8000	78,900	3600
Nagchu	2800–2860	7500–8000	42,000	4500
Shigatse	2600–2860	7500–8000	41,700	4000
Qamdo	2180–2700	6200–6500	10,870	3500
Nyingchi	1750–2010	4590	11,700	3000

- Solar energy resources in western Himalayas, middle and eastern Nagqu Prefecture, Qamdo Prefecture are somewhat less, receiving an annual radiation of 6250–7000 MJ/m^2 and 2250–2900 h of sunshine.
- Solar energy resources in southeastern Tibet follow next, receiving an annual radiation of 5850–6250 MJ/m^2 and 2000–2250 h of sunshine.
- Solar energy resources in the lower reaches of Brahmaputra are least, receiving an annual radiation of less than 5850 MJ/m^2 and less than 2000 h of sunshine (see Fig. 2).

3. Current solar energy applications in Tibet

3.1. Solar thermal utilization

A large number of applications exist in which solar energy is utilized directly by exploiting its heat characteristics. These applications include cooking, heating and cooling of buildings and heating water for domestic and industrial applications. Such technologies are comparatively simple, relatively low cost and easy to adopt and are crucial in reducing the use of precious forest resources as fuel wood. Solar thermal utilization is the technology of choice to avoid deforestation, land desertification, soil erosion, grassland degradation and soil fertility reduction in Tibet [8,11,18].

3.1.1. Solar cooker

A number of public sector organizations, such as the Tibetan Energy Research Center have worked in the past and are still working on the development of low cost and efficient designs of both box and concentrator type solar cookers. The farmers and herdsmen were not willing to use them, since the 1980s government supplied, free solar cookers, considering it stealing from the sun and continued to use traditional biomass stoves. The situation has changed through the efforts of public sector organization and the number of solar stoves in Tibet reached 260,000 by the end of 2007. Solar stove boils 3.8 kg of water by 15 min under normal climatic conditions. It is estimated that per-household reduction in use of firewood is 1000 kg/year [19].

3.1.2. Passive solar building

Passive solar buildings aim to maintain interior thermal comfort throughout the sun's daily and annual cycles whilst reducing the requirement for active heating and cooling systems. Passive solar building can provide indoor thermal environment in winter without consuming any fossil fuel energy and the overheat condition is not serious in summer. Passive solar building heating is important as Tibet belongs to the "Cold Region" in China [20] with very high-energy consumption during the winter. Its use is particular important because inefficient combustion causes high biomass consumption. Passive solar building heating should be applied on a large scale in Tibet, as it reduces traditional biomass consumption.

Passive solar buildings have been constructed in the Ngari and Nagqu district of Tibet since the 1990s. At the end of 2007, Tibet had built solar energy-heated greenhouses and passive solar buildings totaling nearly 3 million square meters [19]. In 2007, an experiment was started by the Tibetan Energy Research center to combine passive solar building and together with advanced insulation technologies in some schools. This experiment showed that solar building technology can make the indoor warmer than outdoor by at least 10 °C, basically meeting winter heating requirements, with added construction cost of about 20%.

3.1.3. Solar water heaters

Use of solar water heaters in Tibet can be traced back to the 1960s, when a solar energy bath was built by the Tibet Industry

Fig. 2. Four zones of solar energy resources in Tibet, China (from www.weatherinfo.com.cn/zy/gnzy.html).

Construction Design Institute, with a 10.3 m^2 water heater. Current solar water heating technology is quite mature and is used extensively in Tibet mainly because of low cost and ease of operation compared to other kinds of solar energy utilization. Data show that solar water heaters in Tibet had reached 400,000 m^2 at the end of 2008 [19].

3.2. Photovoltaic power generation

Tibet has vast land but sparse population. It covers an area of 1.22 million km^2 about 1/8th the size of the USA with a population of only 2.68 million in 2006. The population density is only about 2 persons/km^2 [4]. Taking into account the vast areas and the low population density, small photovoltaic power stations form a more cost-effective solution than expansion of the electricity grid.

3.2.1. Photovoltaic power station in Ngari

Ngari Prefecture, the roof of the Roof of the World (4500 m above the sea level) and the most "Tibetan" part of Tibet, has a population density of 0.27 people/km^2, with about 85% of the population living in rural areas [4]. These villages are separated by large distances with no approach roads. Ngari Prefecture is the only region in China with no stable power supply, and locals have used ghee, a clarified butter, for lighting in their homes and temples, handed down from their ancestors over the past 10 centuries. About 90% of the population has no access to electricity. Obviously, transmission lines are very expensive to build in these areas. Meanwhile, Ngari Prefecture abounds with solar resources receiving an annual average solar radiation of 7000–8000 MJ/m^2 and sunshine for more than 3300 h. Therefore, Ngari Prefecture of Tibet is particularly suited for the utilization of solar energy through photovoltaic power. In 2000, the government invested 60 million Yuan (US $8.8 million) to initiate an electricity project designated the "*Ngari Photovoltaic Project*". The Project has set up more than 60 power stations, big and small, with a combined generating capacity of 250 kW. Also, 12,500 solar panels have been installed in local households. According to local government sources, the use of solar power could save the prefecture more than 10 million Yuan (US $6.8 million) a year in fuel expenditure alone [21].

3.2.2. Development status of PV in Tibet

Since 1980s, Tibet's government has launched a number of programs (see Table 2), such as the "*Brightness Program*", and "*Ngari Photovoltaic Project*" to advance power generation via solar energy and to ease power shortage in the region's countryside. In addition, the Qinghai-Tibet Railway, meteorological stations, cable communications, as well as the People's Liberation Army stationed in Tibet border posts, road have contributed to the large number of photovoltaic power generators.

Tibet is first in China in photovoltaic solar power generation. Statistics show that, up to 2007, 400 solar power plants with generating capacities of 10–100 kW have been built, providing nearly 9 MW electricity. China's first solar station with a 100 kW capacity has been commissioned in Anduo County, Tibet. This station will supply power for 5 h daily during the week and for 24 h on weekends. In addition, the world's highest photovoltaic power station, with capacity of 15 kW, is constructed in the Shuanghu-beicuozhe Township (an altitude of 5600 m) of Tibet, and the world highest wind-solar energy hybrid station, with capacity of 16 kW is set up in Gangni Township, Anduo County (an altitude of 5200 m) of Tibet [18,22].

3.3. Solar–wind hybrids energy

As mentioned above, solar energy in Tibet is abundant, and has been utilized in domains such as lighting system and power generating stations. The applications of stand-alone solar energy have improved the living quality of remote villages' people. However, a common drawback existed for stand-alone solar energy generating power system is its unpredictability depending on uncontrollable weather and climatic conditions. For this reason hybrid systems have been developed to partially overcome these problems. There tends to be significant complimentarity between solar energy and wind energy: good solar irradiation and poor wind energy are provided in summer, and a relatively good wind energy and poor solar irradiation occur in winter. Daytime tends to have high solar irradiation and poor wind energy, nighttime having relative good wind energy with the absence of solar irradiation. Thus hybrid system supply energy at all times, the slack taken up by additional storage technology to overcome unpredictable output of electrical power.

Tibet is rich in wind resource. Estimates of the Climate Center of the Tibet Autonomous Region Meteorological Bureau state the total wind energy reserves in Tibet as 77.3×10^{10} kW [23]. In 1998, Tibetan government collaboration with the Institute of Electrical Engineering, Chinese Academy of Sciences resulted in China's first wind–solar hybrid power system in Zhayi Township, with capacity of 4 kW [24]. A total of 10 wind–solar hybrid power systems have been set up during the "*Rural electrification program* (Chinese name: *Song Dian Dao Xiang*)" [18].

4. Restrictive factors for solar energy future development

4.1. Hydropower challenge

As mentioned above, there are more solar power generators in Tibet than anywhere else in China, with total generating capacity nearly 9 MW. However, the generation of electricity from solar power is unlikely to become widespread for the time being as it is challenged by hydroelectric power.

There are many rivers in Tibet and they form a rich water resources (see Fig. 3). According to the reinvestigation on national water resources, the gross theoretical hydropower potential and annual average energy generation of Tibet is estimated at 201 GW and 1764 TWh/year, respectively. Tibet's gross theoretical hydro-power potential accounts for 29% of the nationwide total, making it the potentially largest hydropower resource in China. The technically exploitable installed capacity and annual average energy generation have been determined approximately as

Table 2
Projects and achievements of Tibet's photovoltaic power generation [18].

Year	Projects and achievements
1987–1989	Set up 3 PV stations with capacity of 1 kW in three counties of Ngari
1990	Set up a PV station with capacity of 10 kW in Geji County of Ngari
1992–1998	Set up 7 PV stations with a total capacity of 420 kW in 7 counties of Ngari and Nagqu
1999–2001	Pilot of "*Brightness Program*". Set up 6 PV stations with a total of 36 kW in 6 townships of Lhasa, Qamdo and Shannan
1999–2001	"*Ngari Photovoltaic Project*". Set up 60 PV stations at the township level and more than 10,000 sets of house-PV system, with a total capacity of 400 kW
2002–2006	"*Rural electrification*". Set up 329 PV stations and *Solar–wind hybrids* systems, with a total capacity of 6763 kW

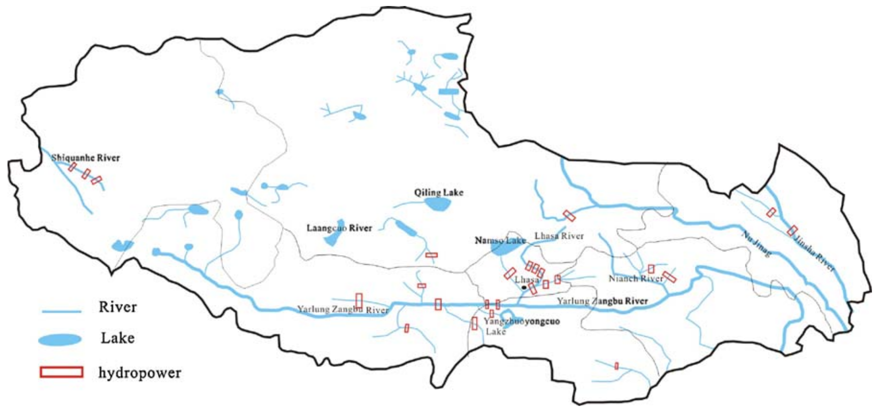

Fig. 3. Hydro sources in Tibet, China (from www.rsscity.com.cn/Scenic/346/detail6316.html).

110 GW and 576 TWh/year, respectively. Tibet's technically exploitable installed capacity accounts for 20.3% of the nationwide total, ranking it second to the Sichuan Province in China [25].

The Tibetan power grid is supported mainly by hydropower, with about four–fifth of power generation coming from hydroelectricity. In 2004, the total installed generating capacity of Tibet amounted to 469 MW, 404 MW of which hydropower. Power generation in Tibet reached 1206 GWh in 2004, of which 1088 GWh was hydropower [26].

New power generation capacity in Tibet's "11th Five-Year Plan (2006–2010)" is mainly from hydroelectricity, whereas other energy resources including solar energy are considered supplementary to hydropower [27]. The giant hydropower projects include the Xueka hydropower station with 40 MW of installed capacity and an investment 700 million Yuan (US $103 million), the Tiger Mouth hydropower station with 100 MW of installed capacity (Tibet's largest single hydroelectric generator) and an investment 1.29 billion Yuan (US $190 million), the Yajiang-zangmu, and Lasazhaxue hydropower stations. Alongside these large and expensive projects, there are also several smaller hydroelectric plants in Tibet. In contrast, only 1.27 billion Yuan (US $187 million) will be invested in building small photovoltaic power stations and distributing adaptable systems to households in Tibet in the "11th Five-Year Plan" [27].

Hydropower stations can provide the people of Tibet with power; however, the construction of these facilities is always controversial. In the rush to build these plants, the policy makers must not overlook environmental impact assessments and protection, and the door should be left open to solar power.

4.2. Talents constraint

With special financial allocations from the central Chinese government, the plateau region has launched a number of programs in the past 30 years to advance solar energy application [28]. However, due to lack of technical know-how and follow-up, these systems have not performed as required.

Solar cookers have been accepted by the majority of farmers and herdsmen in Tibet; however, the overall utilization efficiency of the solar cooker is low due to lack of appropriate technical guidance. Now the solar cooker is mainly used to boil water. Cooking is still carried out using the traditional biomass burning cook stoves. Meanwhile, the low efficiency of solar cookers discourages their extended use [16].

A lack of talents also restricts development of photovoltaic power generation. Several years back, a 10,000 Yuan (US $6800) subsidy from the government allowed local farmer and herdsman to install solar panels in the Ngari Prefecture. A solar panel on a farmer's roof only supplies a few hundred watts of power-enough power for illumination, but nowhere near enough to power appliances such as a refrigerator. Absence of maintenance technicians, caused some solar panels to fall into disuse just after 1 or 2 years—an awkward fact for developing a new source of energy [8].

Lack of technicians has become a bottleneck in solar energy applications. It is urgent to train local technicians for management and maintenance of solar equipments, especially PV equipments. A new curriculum concerning solar energy should be set up in the Tibet University and other universities to train maintenance personnel. Meanwhile, with fund from the local government, a number of local active research persons should have an option to study at research institutes in China's developed areas or even abroad. Finally, a technical training agency should be established to train technical personnel in expanding utilization of solar energy in agricultural and pastoral areas.

4.3. Policy and administrative barriers

Investment of solar energy utilization in Tibet comes almost entirely from the Central government. However, the Central government's support policy for PV in Tibet has decreased, as its investment in hydropower has increased. The installed PV generation has therefore not achieved the desired results for lack of technical support. In 2005, the Chinese Renewable Energy Law was passed and the law's implementing regulations support PV rapid growth elsewhere. For example, China will construct a 10 MW solar photovoltaic (PV) power generation plant in Dunhuang of Northwest China's Gansu Province in 2009 [29]. Currently, the central government favors hydropower over PV in Tibet and there will therefore not be an ambitious development plan during the current 11th Five-Year Plan, PV generation continuing to be relegated to being supplementary to hydropower.

Meanwhile, Tibet's local government has paid more attention to the construction of PV generation station than to administrative and technical follow-up, resulting in not functioning of a number of PV stations. For example, the Song Dian Dao Xiang program constructed several hundred village systems based on PV and PV–wind in Tibet between 2002 and 2006. There were systemic problems with those systems that have not been entirely resolved yet, and need to be solved before larger scale PV system deployment can be successful. Such problems are associated with system operation and maintenance, viable regulations for tariff setting and revenue collection, and long-term government support for continued system operation.

In the future, central government should recognize the pertinence of solar energy utilization, prioritize it accordingly and increase investment. Meanwhile, the local government should develop a medium and long-term plan of solar energy utilization, especially focused on systems operation and maintenance.

5. Conclusion

Solar energy is a renewable energy source nearly inexhaustible and pollution-free. Solar energy application can increase clean energy supply and reduce pollutant emission, which is helpful to establish a sustainable energy system necessary to maintain the socio-economic development in Tibet. Tibet is affluent in solar resources and has a high development potential for solar energy applications. Meanwhile, Tibet's precious and fragile ecosystem is confronting gigantic challenges because of the near-exponential rise in tourist numbers and rapid economic growth, making prioritizing solar energy development a must. To advance solar energy application smoothly, local technicians should be trained. In this way, Tibet can aspire towards a sustainable balance between economic development, booming tourism and environmental protection, not only benefiting the local sustainable development, but also facilitating the Chinese, South and Southeast Asian future development.

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References

[1] State Council Information Office of China, Ecological Improvement and Environmental Protection in Tibet. Beijing: State Council Information Office of the People's Republic of China; 2003.
[2] Tibet Statistical Yearbook-2008. Tibet Statistical Yearbook-2008. Lhasa: Tibet Autonomous Bureau of Statistics and Tibet General Team of Investigation under the NBS; 2008 [in Chinese].
[3] Peng C, Ouyang H, Gao Q, Jiang Y, Zhang F, Li J, et al. Building a "Green" railway in China. Science 2007;316:546–7.
[4] Tibet Statistical Yearbook-2007. Tibet Statistical Yearbook-2007. Lhasa: Tibet Autonomous Bureau of Statistics and Tibet General Team of Investigation under the NBS; 2007 [in Chinese].
[5] National Energy Bureau of China. Energy condition and development in Tibet. Beijing: National Energy Bureau of China; 2006 [in Chinese].
[6] China Energy Statistical Yearbook-2007. China Energy Statistical Yearbook-2007. Beijing: Department of Industry and Transport Statistics, National Bureau of Statistics and Energy Bureau, National Development and Reform Commission of China; 2007.
[7] Zhou S, Zhang X. Prospect of briquetting biomass fuel by forest residues in Tibet. Korean Journal of Chemical Engineering 2007;24:170–4.
[8] Liu G, Lucas M, Shen L. Rural household energy consumption and its impacts on eco-environment in Tibet: taking Taktse county as an example. Renewable and Sustainable Energy Reviews 2008;12(7):1890–908.
[9] Junfeng L, Runqing H, Yanqin S, Jingli S, Bhattacharya SC, Abdul Salam P. Assessment of sustainable energy potential of non-plantation biomass resources in China. Biomass and Bioenergy 2005;29(3):167–77.
[10] Chen H-J, Feng H-L. On the land regenerated energy resources of China and their characteristic. Journal of Nature Resources 1991;6(2):97–106 [in Chinese].
[11] Wei X-H, Yang P, Wang Y-J, Xie Z-K. Use of rural energy resources and eco-environmental degradation in Tibet. Journal of Environmental Sciences 2004;16(6):1046–50.
[12] Xu Z-R, Cheng S-K, Min Q-W, Zou X-P. An evaluation on basis of resource and environment for developing bio-energy in Tibet. Journal of Natural Resources 2007;22(2):243–50 [in Chinese].
[13] Tsoutsos T, Frantzeskaki N, Gekas V. Environmental impacts from the solar energy technologies. Energy Policy 2005;33(3):289–96.
[14] Various. In: Karapanagiotis N, editor. Environmental impacts from the use of solar energy technologies. THERMIE; 2000.
[15] Wang Y-Q, Basang L, Yang Y-J. Thinking over adjustment of energy structure in Tibet. Central South Forestry Inventory and Planning 2007;126(1):60–3 [in Chinese].
[16] Wang Y-Q, Wang J-L. Tibet solar energy develop existing problem and several suggestions. Tibet's Science & Technology 2007;166(2):26–8 [in Chinese].
[17] Li W-H. Development of renewable energy and rural sustainable development in Tibet. Energy of China 2008;30(9):40–2 [in Chinese].
[18] Cai G-T, Zhang L. Research on Tibet rural energy consumption and its environmental impact. Resource Development & Market 2006;22(3):238–41 [in Chinese].
[19] Li J-X, Ma J-H. Review development of renewable energy in Tibet in late 30 years. Tibet Daily, or available from: http://tibet.cn/news/xzxw/kjtw/200811/t20081103_436056.htm. [in Chinese] 2008.
[20] Chen R-S, Kang E-S, Ji X-B, Yang J-P, Yang Y. Cold regions in China. Cold Regions Science and Technology 2006;45(2):95–102.
[21] Laba C. Ngari end the history of no electricity. Xinhua News Agency; 2003-06-03, or available from: http://news.xinhuanet.com/newscenter/2003-06/03/content_901827.htm. [in Chinese].
[22] People's Daily, Tibet leads nation in solar energy development. People's Daily; 2006-11-27, or available from: http://nc.people.com.cn/GB/61156/61926/5090537.html. [in Chinese].
[23] Zhang H, Ge S, Lu H. Analysis of wind energy resource in Tibet. Tibet's Science & Technology 2005;143(3):33–4.
[24] Li P, Xu H-H, Liu G-Q. Development of 4 kW wind/PV hybrid generation system in Tibet, China. New Energy Sources 1998;20(10):10–3 [in Chinese].
[25] Wang M, Guo X, Guo J. Research on hydropower and economic development of the Tibetan Autonomous Region. Water Power 2006;32(12):1–4 [in Chinese].
[26] China Electric Power Yearbook. China Electric Power Yearbook-2005. Beijing: China Electric Power Press; 2005.
[27] Tibet Autonomous Region Government. Tibet autonomous region "11th Five-Year Plan" national economic and social development plan. Lhasa: Tibet Autonomous Region Government; 2006 [in Chinese].
[28] People's Daily, Central Government helps Tibet develop economy and society. People's Daily Online; 2008-04-01, or available from: http://english.peopledaily.com.cn/90001/90776/90785/6384840.html.
[29] Liang Z. 38 enterprises participating in bid, China's largest PV power generation project to start. 21th Century Business Herald; 2009-02-04, or available from http://www.china5e.com/newenergy/newenergynews.aspx?newsid=e5f2f773-cf55-408e-885d-cc8cb8758be7&classid=%u65b0%u80fd%u6e90. [in Chinese].